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Identification of Cost Factors for the Ocean Disposal Alternative for Low-Level Radioactive Waste

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IDENTIFICATION OF COST FACTORS FOR THE OCEAN DISPOSAL ALTERNATIVE FOR LOW-LEVEL RADIOACTIVE WASTE

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MARCH 1983

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The major cost factors are identified for several alternatives for the disposal of contaminated soils and neutron activated metallic structure.

A program for the actual cost analysis is outlined, and manpower estimates for the studies are presented.

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1. ECONOMIC GROUND RULES FOR COST COMPARISONS

The comparison of the economic costs of various alternatives for disposing of low-level radioactive wastes is an important element in the evaluation of environmental impact statements (EIS). To be valid, such cost comparisons must be based on a standard set of economic rules. Cost estimates appearing in numerous technical and engineering reports must be reduced to a common basis before the comparisons can be made. The purpose of this section is to set forth a proposed set of economic rules that will allow the raw cost data to be converted to a common basis.

1.1 Constant Dollars:

All cost comparisons shall be made in terms of 1980 constant dollars. Cost estimates made in prior years shall be escalated to 1980 constant dollars from the effective cost-basis-date by means of the inflation factors given in Table 1.1.

Table 1.1 Implicit Price Deflators for Gross National Product (1980=100)
(Source: Department of Commerce, Bureau of Economic Analysis)

Period	Deflator	Period	Deflator
1971	53.7	1977	78.4
1972	56.0	1978	84.2
1973	59.2	1979	91.5
1974	64.4	1980	100.0
1975	70.4	1981	109.4
1976	74.1	1982	116.0

Some reports on disposal alternatives may contain estimates of future costs. If so, the data must be converted to 1980 constant dollars using the economic assumptions contained in that particular report. If such assumptions are not stated explicitly, an investigation must be conducted to ascertain the procedures used by the authors in arriving at an estimate for future costs.

Often it is impossible to determine the economic basis for cost estimates cited in reports, e.g., whether the costs are given in current dollars as of the date of the report or on some other basis. Every effort must be made to eliminate such uncertainties, e.g., by contacting the authors of the reports.

1.2 Cost Changes Due to Changing Circumstances:

Often the cost estimates made in prior years are based on assumptions that are no longer valid. For example, changing regulations, revised disposal price schedules at shallow land burial sites, and increased transportation costs have resulted in disposal cost increments which have greatly exceeded general inflation rates. All cost estimates must be examined to determine the present and near-future validity of the underlying assumptions. Whenever possible the original cost estimates must be revised to account for changing circumstances. Cost data which cannot be so corrected should not be used for cost comparisons.

1.3 Present Value:

Cost that will be incurred in future years shall be reduced to present value for comparison purposes. Unfortunately, there is no consensus among economists about an appropriate discount rate to use for present value calculations of government investments. Therefore, we recommend that two present value calculations be made so as to bracket the range of possible discount rates. One calculation should be made using a rate of 0%, the other using a 10% rate. In the event these two extremes have serious impact on cost comparisons, intermediate discount rates can be used to determine the crossover point in the cost of two options.

Note that the present value calculations are additional steps to the normalization to 1980 constant dollars. The rationale is that monies to be spent in the future can be used to earn interest from the present until the point in time when they must actually be spent. The formula for calculating present value is:

$$C_o = C_i/(1 + R)^n ,$$

where C_o is the present value, C_i is the cost in calendar year i, R is the discount rate, and n is the number of years between now and the year i. C_o and C_i are both expressed in 1980 constant dollars.

1.4 Cost Factors:

Cost factors to be considered in making cost comparisons between various disposal options fall under the general categories described in the following sections. All costs are to be normalized to 1980 constant dollars and future costs are to be expressed in the two units of present value (0% and 10% discount rates).

1.4.1 Capital Investments:

Facilities which have to be constructed and major equipment which must be purchased represent capital investments. Capital investment costs shall include the costs of:

- administration
- land acquisition
- facility licensing
- engineering and design
- equipment purchased
- construction labor
- construction materials
- interest on funds spent during construction
- profit margin for contractors

The summation of all costs expressed as present value in 1980 constant dollars equals the capital investment.

The useful life of the capital equipment must be estimated to assure its availability throughout the time it is needed. If the facility is shared by several disposal operations, the capital cost should be allocated appropriately.

1.4.2 Sunk Costs:

Facilities that already exist and can be used in the disposal operation represent sunk costs. The capital investments made in the past to construct such facilities should not be included in the cost analyses.

Any modification to existing facilities that might be required for the disposal operation represent new investment and must be included in the cost analysis either as a capital investment or as an operational cost.

1.4.3 Operating Costs:

Operating Costs shall include:

- administration
- labor
- supplies
- transportation
- abatement and restoration
- monitoring and surveillance
- profit (for private contractors)
- insurance

1.4.4 Externalities:

The costs of externalities shall not be included in the cost analyses. By externalities is meant the impact of air or water pollution, degradation of amenities, population health effects etc. Such

externalities are presumably taken into account in other sections of the environmental impact statement. However, all abatement operations that are required shall be included as part of the operating costs. These might include dust suppression, water effluent clean-up, land restoration, and protection measures to avert public health impacts.

1.4.5 Decommissioning of Facilities:

The cost of decommissioning process facilities and equipment, and of disposing of contaminated items shall be included in the cost estimates.

1.4.6 Long-Term Monitoring and Surveillance:

The cost of long-term monitoring and surveillance of the disposal site shall be included.

1.4.7 Opportunity Costs:

Land areas used for shallow land burial disposal must be withdrawn from public use for prolonged periods of time. The economic loss suffered by not having the land available for other purposes (e.g., agriculture, recreation, forest products) constitutes the opportunity cost which shall be included in the cost comparisons.

2. IDENTIFICATION OF COST FACTORS IN THE DISPOSAL OF CONTAMINATED SOILS

2.1 Background Information:

During and immediately following World War II, various contractors of the federal government processed domestic and imported ores to extract uranium and thorium needed for the developing nuclear weapons programs. This work was carried out at several sites in the continental United States under the auspices of the Army Corps of Engineers, Manhattan Engineer District (MED) and later under the U.S. Atomic Energy Commission (AEC). The residues from these operations contain several radioactive and stable toxic elements in concentrations that are small but nevertheless exceed the present public health standards for unrestricted use of the sites. At the present time the U.S. Department of Energy (DOE) bears the responsibility for corrective actions at these sites. The work is being conducted under the DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP).

The peculiar nature of the FUSRAP wastes have a major impact on the costs of alternative disposal options. These wastes are composed of materials in which the radioactivity and chemically-toxic elements are:

- very dilute (mixed with soil, rubble, etc.)
- of natural origin (not man-made) isotopes or chemicals, and
- normally present in most regions of the world (but in lesser concentration).

2.2 FUSRAP Disposal Alternatives:

Five disposal options will be considered:

1). Ocean disposal: dispersion of loose soil at a deepwater dumping site (e.g., at DWD-106)

2). Ocean disposal: containment to sea bottom at a deepwater dumping site (e.g., at a 5200 meter depth site southwest of Cape Hatteras)

3). Land disposal: burial of loose soil at a shallow land burial site (SLB)

4). Land disposal: burial of packaged soil at a shallow land burial site.

5). Land disposal: stabilization in place.

2.3 Cost Factors:

The cost factors associated with each disposal option are listed below. Detailed cost factors will differ for each option, as shown by the comparison in Table 2.1.

1. Administration and Planning

   a. Administrative staff
   b. Engineering and planning
   c. Legal actions to obtain permits
   d. Preparation of environmental impact statement
   e. Supervision of operations

2. Operations

   a. Residue retrieval
   b. Packaging of wastes (if required by option)
   c. Loading for transport
   d. Transportation to disposal site
   e. Unloading at disposal site
   f. Monitoring of disposal operation

Table 2.1 COMPARISON OF COST FACTORS—CONTAMINATED SOILS

NO ACTION	LAND DISPOSAL	SEA DISPOSAL
Quantities of contaminated residues Sources: number and location		
Opportunity cost of restricted land and property Measures for stabilization in place • initial • continuing • recurring Long-term site monitoring and surveillance	Location of disposal sites Disposal site extension or new site studies & licensing Land transportation permit Interim storage sites • location • ownership • maintenance • NRC licensing Opportunity cost of land used for disposal Residue retrieval Containerization • drums • bulk transporters Overland transporters • loadings • unloadings Disposal Original site restoration Long-term site monitoring and surveillance	Location of embarkation ports Land transportation permit Interim storage site • location • ownership • maintenance • NRC licensing EPA permit for sea disposal Specific international consultatons as required Possible EIS Additional oceanographic services for site select'n Residue retrieval Containerization • for dispersion • for containment to sea bottom Overland transportation • loadings • unloadings Sea transportation • loadings • disposal Original site restoration
ACCIDENT REGIMES		
Normal use Restricted use	Retrieval of contaminated soil Containerization Loadings Transportation Unloadings Disposal	Retrieval of contaminated soil Containerization Loadings Overland transportation Unloadings Sea transportation Disposal

3. Site Restoration and Survey (of original FUSRAP site)

a. Radiological survey of site
b. Backfill of excavated areas
c. Restoration of vegetation
d. Final approval for unrestricted use of site.

4. Disposal Site Long-Term Costs

a. Long-term monitoring and surveillance of disposal site
b. Opportunity cost of land used for disposal (land disposal options only).

2.4 Discussion of Cost Factors for Each Option:

2.4.1 Ocean Disposal: Dispersion of Loose Soil:

For this option, engineering and planning efforts are minimal. Legal permits are required to move the waste material from the site to the nearest seaport via truck or rail. These must be obtained from the Department of Transportation and the Coast Guard. A permit to use an existing Deep Water Dumping site must be obtained from the EPA. An environmental impact statement (EIS) will probably be required.

Since packaging is not used, the material can be loaded directly into dump trucks which transfer the material directly to the seaport. For some sites more distant from the coast, the material must be transferred from trucks into covered rail hopper cars for transport to the seaport. Since specific radioactivity (curies/cubic meter) is very low, trucks covered by a tarpaulin would adequately retain the loose soil. At the seaport the soil is loaded on dump scows which are towed to the disposal site by tugs.

Monitoring in the vicinity of the dump site will be required to verify that the spoil sinks and does not get carried by currents to some unexpected locations. Long term monitoring and surveillance requirements would be minimal.

As in all options the original site must be restored for unrestricted use by conducting a radiological survey to verify that the residual radiation levels are acceptable, by backfilling excavations, and by restoring vegetation.

2.4.2 Ocean Disposal: Containment to Seabottom:

This option requires several extra steps over the dispersion-of-loose-soil option. Permits for land and sea transportation must be obtained. In addition, a permit must be obtained from EPA to open a new deepwater disposal site. An EIS would be required.

Practical containers must be selected and provisions made for filling and handling the loaded containers. Transfer from land to sea transporters would require more complicated handling equipment. Disposal site monitoring and surveillance would be necessary.

Restoration of the original site would require the same steps as the dispersion-of-loose-soil option.

2.4.3 Land Disposal: Burial of Loose Soil at a Shallow Land Burial Site:

Existing shallow land burial (SLB) sites have limited available capacity. Therefore, it must be assumed that an existing SLB would have to be extended or a new site licensed. Either alternative would require extensive studies to characterize the geological and hydrological properties of candidate sites and verify that the buried material would be permanently contained (because of the long half-lives of the radioactivity). This implies a site located in an arid climate in the western U.S., which in turn implies overland transport for long distances. The

disposal site would not be available for unrestricted use, and, therefore, an opportunity cost for the dedicated land must be considered. Long-term monitoring and surveillance of the site would probably be necessary for political reasons, although the radioactivity in the disposal site would be comparable or less than natural uranium ore outcroppings found in many locations in the country.

Restoration of the original site would be the same as in the other options.

2.4.4. Land Disposal: Burial of Packaged Soil at a Shallow Land Burial Site:

This option would require the several extra cost items cited in Section 2.4.2 above related to packaging the material. The packaging would probably simplify the obtaining of permits for overland transport, but would provide no long-term benefits after burial over the SLB-burial-of-loose-soil option (Section 2.4.3). This is because the containers would fail after a few years (by rotting or corrosion) and the buried material would become equivalent to loose soil. Thus, a SLB site in a humid location would still be precluded.

2.4.5 Land Disposal: Stabilization in Place:

The stabilization-in-place of FUSRAP residues must be viewed as a temporary measure, because the radioactivity would long outlast any stabilization measures. Eventually the base pads, the covering material and the water recycling measures would fail and the residue would be once again subject to water and wind erosion. Thus, in addition to the opportunity costs of the land dedicated to stabilization in place, the cost of long-term maintenance of the "stabilized" waste pile must be included.

For this option the cost of land restoration would be included as a part of the long-term maintenance program.

2.5 Accident Regimes:

Industrial-type accidents would be associated with the retrieval, packaging, loading, and unloading of the contaminated soil. These can be estimated from national statistics for similar operations, based on the volume and/or tonnage of material handled and the number of handlings.

Accidents would also be expected during highway, rail or sea transport. The probabilities of such accidents can be assumed to be proportional to ton-miles which can be estimated from national transportation statistics, and to the number of handlings. Because of the very dilute nature of the radioactivity contained in the soils, there would be no significant radiological risk associated with a transportation accident.

2.6 Compliance with State and Local Regulations:

The impact of state and local regulations on the various disposal options, if any, is a clouded legal issue at the present time.

In the Hazardous Materials Transportation Act, Congress granted broad powers to the Department of Transportation to regulate overland transportation of radioactive materials. These powers are under challenge in the Courts and might not be finally decided for many years. For example, in February 1982 a Federal District Court judge upheld the right of the City of New York to promulgate regulations that are more restrictive than the DOT regulations. This case, now under appeal, could set a precedent for other local entities in the event that federal preemption of transportation is not upheld.

The nature of local and state restrictions on the movement of highway shipments of radioactive materials include:

- prohibition of movement through certain localities;
- specification of routes shipments must follow;
- times of day or week shipments can pass through certain localities, and
- advance notification of specific public officials.

Commercial carriers of waste are meeting these restrictions, although often at greatly increased costs due to en route delays and increased mileage due to long detours.

In addition, the Low-Level Radioactive Waste Policy Act of 1980 (Public Law 96-573) empowers the States (or regional compacts of States) to restrict the use of state or regional disposal sites to radioactive waste generated within the boundaries of the State (or compact region). It appears that FUSRAP wastes would be excluded from these restrictions under Sections 3(a) and (b) of PL 96-573; however, some court tests might be expected, since many of the FUSRAP sites are owned by private companies. Litigation in this area might seriously delay the implementation of the land disposal options.

3. IDENTIFICATION OF COST FACTORS IN THE DISPOSAL OF RADIOACTIVE METAL STRUCTURES

It is assumed that the terminology "radioactive metal structures" refers to the reactor compartments of government-owned nuclear powered ships and submarines and land-based prototypes (if any).

3.1 Background Information:

Nuclear reactors produce radioactive isotopes in two significant ways:

1). The fission products of the uranium and plutonium in the fuel; and

2). From neutron-induced nuclear reactions in the coolant and reactor structures (commonly referred to as "activation products").

3.1.1 Fission Product Contamination:

The fission products constitute the overwhelming bulk of the radioactive inventory of a reactor. Most of the fission products remain trapped in the fuel elements and are discharged when the spent fuel is removed from the reactor. However, a small fraction of the fission products escape from defective fuel elements and contaminate the surface layers of the reactor internal components and the interior of the pipes in the primary coolant loops. When the reactor is decommissioned, most surface contamination can be removed by routine decontamination procedures; although some "crud" deposits build up which defy practical cleaning methods. Thus some residue of fission product contamination would be the normal expectation, unless "heroic" decontamination procedures are used.

3.1.2 Activation Product Contamination:

Because of the fact that neutrons have no electric charge, they can penetrate through relatively large thickness (e.g., several centimeters) of most materials before being absorbed. The absorption process occurs by means of some type of nuclear reaction which usually results in a product atom that is radioactive. Thus in a heavy metal section exposed to a flux of neutrons, the resultant radioactivity will be distributed through the body of the material (as opposed to surface contamination). The concentration of radioactivity will decrease with the depth of penetration.

The variety of isotopes produced by neutron-induced reactions depends not only on the elements exposed to the neutron flux, and the total neutron exposure over all operating time, but also on the neutron energy spectrum. The inventory of neutron activation products in the reactor structure at the time of decommissioning and at all later times can be calculated using existing computer programs. Such calculations must take into account the geometrical arrangement of each reactor component, their composition or alloy, and the operational history of the reactor. The results of such a calculation for a commercial reactor are shown in Table 3.1.

For components which have been intensely irradiated, for example, the reactor shroud at the core center plane, total specific activities as high as 360 Ci/kg have been calculated for a typical commercial reactor. This inventory includes 117 Ci/kg of ^{55}Fe, 42.6 Ci/kg of ^{60}Co and 11 Ci/kg of ^{63}Ni. The specific activity of other components is far less.

The estimated total neutron-induced radioactivity for a nominal commercial reactor after operating for 30 years is in the range of 6.6×10^{6} Ci at time of shutdown. After 100 years of decay time this inventory has decreased to 9.7×10^{4} Ci. The bulk of the 100 years residual activity consists of 9.6×10^{4} Ci of ^{63}Ni and 1.47×10^{3} Ci of ^{59}Ni.

Table 3.1 Typical Radionuclides Found in Neutron Irradiated Carbon and Stainless Steels.
Several of the isotopes are produced from trace elements present in the alloys. Isotopes of less than 0.5 years half-life have been omitted.

ISOTOPE	HALF-LIFE (years)	FRACTION OF TOTAL ORIGINAL RADIOACTIVITY AT: SHUTDOWN	100 YEARS DECAY
^{14}C	5730	3.68×10^{-5}	3.64×10^{-5}
^{54}Mn	0.85	2.98×10^{-3}	___ a)
^{55}Fe	2.7	3.24×10^{-1}	___
^{60}Co	5.27	1.18×10^{-1}	2.20×10^{-7}
^{59}Ni	7.5×10^{4}	2.23×10^{-4}	2.23×10^{-4}
^{63}Ni	100	3.07×10^{-2}	1.45×10^{-2}
^{93m}Nb	13.6	4.74×10^{-8}	9.61×10^{-8} b)
^{94}Nb	2×10^{4}	5.26×10^{-7}	5.26×10^{-7}
^{93}Mo	3×10^{3}	1.14×10^{-7}	1.13×10^{-7}

Note: Other isotopes remaining after 100 years of decay in fractions of less than 10^{-7} of the original total radioactivity include ^{99}Tc, ^{108m}A, ^{108}Ag, ^{151}Sm, ^{154}Eu and ^{166m}Ho.

a)
less than 1×10^{-10}.

b)
^{93m}Nb grows-in from decay of parent ^{93}Mo.

Thus, the two isotopes of nickel, ^{63}Ni and ^{59}Ni constitute the main long term activity of these, ^{63}Ni decays with a soft beta emission (0.067 MeV) and will decay to negligble levels in about 1000 years. The half-life of ^{59}Ni is 75,000 years so its decay will not be significant in the time scale of human history. It decays by electron capture yielding internal bremsstrahlung of maximum energy of 1.07 MeV.

For deep ocean disposal, the material itself serves as a barrier against disposal of the radioactivity. The ultimate release of radioactivity into the ocean environment will depend on the corrosion rates of the surrounding materials (e.g., the hull of a ship) that must be breached before exposing the radioactive components to seawater, and the corrosion rate of the radioactive components themselves.

3.2 Disposal Options for Reactor Components of Decommissioned Nuclear-Powered Ships:

Three disposal options will be considered:

1). Ocean Disposal: Scuttle ships at deep ocean disposal site,

2). Land Disposal: Remove radioactive sections of ship for disposal at a DOE burial site, and

3). Permanent mothballing of ships.

3.3 Cost Factors:

The general cost factors common to the three options are:

1). Administration and Planning

Administration
Engineering Planning
Legal Actions to Obtain Permits

2). Operations

3). Long-Term Monitoring and Surveillance.

Of course, the actual costs associated with each option will differ. More detailed lists of cost factors are given in the following sections, and are compared in Table 3.2. In each case it is assumed that during decommissioning the reactor core has been removed and that most of the surface contamination has been removed from the reactor interior and the primary coolant loops by standard decontamination procedures.

3.3.1 Ocean Disposal Cost Factors:

In this option, it is assumed that, following decommissioning, the vessel is made seaworthy, prepared for scuttling, towed to the disposal site and sunk. The special cost factors identified for ocean disposal are:

1). Legal actions required to obtain a dumping permit from EPA.

2). Oceanographic research to select and characterize the disposal site, including collection of data required for permit and EIS.

3). Preparation of an EIS.

4). Long-term monitoring and surveillance of disposal site.

5). Loss of salvage value of vessel hull.

Local and state regulations would not affect this option.

Table 3.2 COMPARISON OF COST FACTORS—SUBMARINE DISPOSAL

NO ACTION (Indefinite protective storage)	LAND DISPOSAL	SEA DISPOSAL
Number, sizes, and estimated timing of nuclear submarines to be decommissioned.		
Mothballing Towing to storage site Direct maintenance in storage Opportunity cost of shipyard space used for storage Long-term site monitoring and surveillance Postponed recoupment of salvage value	Design, licensing, construction, operation and decommissioning of dismantling facility Removal of reactor compartment Barge or overland transport • rate • preparation for shipment • distance • loading & unloading Disposal operations Opportunity cost of land used for disposal Long-term site monitoring and surveillance Protective storage of existing decommissioned submarines (≈ 3-5 years)	Loss of scrap value EPA permit for specific site International consultations under London Ocean Dumping Convention, etc. Restoring hull integrity Preparation for towing & flooding Towing: distance & rate Additional oceanographic measurements for site selection Additional corrosion studies specific to sea disposal Long-term site monitoring and surveillance Protective storage of existing decommissioned submarines (≈ 5-8 years) Sinking
ACCIDENT REGIMES		
Protective storage Towing (if necessary) (plus ultimate disposal)	Protective storage Reactor removal Preparation for shipment Loadings Transport Unloadings	Protective storage Preparation for towing & and shipping Towing Sinking

3.3.2 Land Disposal Cost Factors:

For the land disposal option it is assumed that following decommissioning the vessel would be made seaworthy, and towed to a graving dock for dismantling. Noncontaminated parts of the hull would be sold as scrap. The contaminated section of the power plant would be removed for transport. This section would be moved by a combination of barge and overland shipment to a federally-owned burial site.

The special cost factors associated with the land disposal option are:

1. Legal actions to obtain transport permits.

2. Capital construction and equipment costs of drydock facility augmentation.

3. Specialized labor for hull sectioning.

4. Radiation protection during hull sectioning.

5. Barge and overland transport costs.

6. Disposal site labor.

9). Long-term maintenance, monitoring and surveillance of disposal site.

10). Decommissioning and restoration of the dismantling facility.

11). Opportunity costs of the land dedicated to the burial site(s).

3.3.3 Mothballing Cost Factors:

The mothballing of decommissioned nuclear ships is not actually a disposal procedure but merely a postponement of one of the other disposal alternatives. A long delay (e.g. 100 years) in disposal through mothballing would offer some advantage to the land disposal option because a large part of the troublesome radioactivity would decay away, particularly the ^{60}Co. The special costs associated with this option would include:

1). Engineering design of mothballing procedures.

2). Materials and labor for mothballing.

3). Towing the vessel to a harbor with adequate storage space.

4). Maintenance of mothballing and moorings.

5). Monitoring and surveillance.

6). Opportunity costs of occupied harbor space.

7). Ultimate disposal.

3.4 Accident Regimes:

3.4.1 Ocean Disposal:

Accident scenarios associated with ocean disposal would all be involved with the towing operation. These would include grounding, collision, and premature sinking.

3.4.2 Land Disposal:

The accident regimes associated with land disposal are somewhat broader and would include mishaps in towing from decommissioning location to the dismantlement site, perhaps involving two harbors and a coastal passage. At the dismantling facility in addition to conventional industrial-type accidents, there would be the risk of excessive radiation exposures to workmen. The barge and overland transportation would be subject to various obvious potential accidents.

3.4.3 Mothballing:

The accident regimes associated with mothballing would be related to the towing operation in moving the vessel from the decommissioning harbor to the storage harbor (if necessary) and at the long term storage moorings (e.g., sinking at the mooring, going adrift in foul weather). Also, account should be taken of accident regimes associated with the ultimate disposal.

3.5 Compliance with State and Local Regulations:

It is unlikely that any of the three disposal options would involve steps that come under local or state jurisdiction. An exception might occur in the land disposal alternative during overland transport of radioactive materials. However, it is likely that the material would travel by barge from the coastal dismantling facility, on the high seas to the Pacific coast, then up the Columbia River to the federal Hanford reservation. If this were the case, overland transportation would be limited to the Hanford site itself, from the land to the burial site.

4. OUTLINE OF A PROGRAM FOR ACTUAL COST ANALYSIS

The detailed cost comparisons between various disposal options will require the following steps:

1). Assemble and document detailed cost data from various engineering studies.

2). Reduce all cost factors to a common cost basis, applying the economic ground rules presented in Section 1.

3). Prepare a documented report showing the procedures used and the original and normalized cost data.

Estimated manpower required for carrying out the work cited in the above steps is given in Table 4.1.

Table 4.1 Estimated Professional Manpower to Complete Detailed Cost Analysis of Disposal Alternatives.

Task	Contaminated Soils	Submarine Disposal
	(man-months)	
1. Assemble Data for Engineering Studies	1.0	2.0
2. Cost Analysis	1.0	1.5
3. Report Preparation	1.5	1.5
Total	3.5	5.0